mentioned aspect of the present invention.

A semiconductor optical modulator according to still another aspect of the present invention includes a first optical directional coupler on a semiconductor substrate; a second optical directional coupler on said semiconductor substrate; a first optical waveguide; a second optical waveguide; a wave-coupling region for the first waveguide and the second waveguide between the directional couplers; a pair of traveling-wave electrodes, said traveling-wave electrodes having no crossover; and two sets of air-bridge structures forming connections between the waveguide region and the traveling-wave electrodes.

The other objects, features and advantages of the present invention are specifically set forth in or will become apparent from the following detailed descriptions of the invention when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a prior art reverse delta beta type directional coupler modulator.

FIG. 2 is a prior art reverse delta beta type traveling-wave directional coupler modulator;

FIG. 3 is a directional coupler modulator according to a first embodiment of the present invention;

FIG. 4 is a cross-sectional view of the directional coupler modulator according to the first embodiment;

FIG. 5 is a directional coupler modulator according to a second embodiment of the present invention;

FIG. 6 is a cross-sectional view of a directional coupler modulator according to a third embodiment of the present invention;

FIG. 7 is a top view of a directional modulator according to the third embodiment of the invention;

FIG. 8 is a cross section of a directional coupler modulator according to a fourth embodiment of the present invention;

FIG. 9 is a cross section of a directional coupler modulator according to a fifth embodiment of the present invention;

FIG. 10 is a directional coupler modulator according to a sixth embodiment of the present invention;

FIG. 11 is a directional coupler modulator according to a seventh embodiment of the present invention;

FIG. 12 is a directional coupler modulator according to an eighth embodiment of the present invention;

FIG. 13 is a directional coupler modulator according to a ninth embodiment of the present invention;

FIG. 14 is a directional coupler modulator according to a tenth embodiment of the present invention;

Fig. 15 is a directional coupler type modulator according to an eleventh embodiment of the present invention;

Fig. 16 is a directional coupler type modulator and a directional coupler according to a twelfth embodiment of the present invention;

Fig. 17 is a graph of DC voltage against light emission output

FIG. 5 is a directional coupler modulator according to a second embodiment of the present invention;

FIG. 6 is a cross-sectional view of a directional coupler modulator according to a third embodiment of the present invention;

FIG. 7 is a top view of a directional modulator according to the third embodiment of the invention;

FIG. 8 is a cross section of a directional coupler modulator according to a fourth embodiment of the present invention;

FIG. 9 is a cross section of a directional coupler modulator according to a fifth embodiment of the present invention;

FIG. 10 is a directional coupler modulator according to a sixth embodiment of the present invention;

FIG. 11 is a directional coupler modulator according to a seventh embodiment of the present invention;

FIG. 12 is a directional coupler modulator according to an eighth embodiment of the present invention;

FIG. 13 is a directional coupler modulator according to a ninth embodiment of the present invention;

FIG. 14 is a directional coupler modulator according to a tenth embodiment of the present invention;

Fig. 15 is a directional coupler type modulator according to an eleventh embodiment of the present invention;

Fig. 16 is a directional coupler type modulator and a directional coupler according to a twelfth embodiment of the present invention;

Fig. 17 is a graph of DC voltage against light emission output

ratio according to the twelfth embodiment;

Fig. 18 is a directional coupler type modulator according to a thirteenth embodiment of the present invention;

Fig. 19 is a directional coupler type modulator according to a fourteenth embodiment of the present invention;

Fig. 20 is a cross section of the directional coupler type modulator according to the fourteenth embodiment;

Fig. 21 is a cross section of a directional coupler type modulator according to a fifteenth embodiment of the present invention;

Fig. 22 is a directional coupler type modulator according to a sixteenth embodiment of the present invention;

Fig. 23 is a cross section of the directional coupler type modulator according to the sixteenth embodiment;

Fig. 24 is a directional coupler type modulator according to a seventeenth embodiment of the present invention; and

Fig. 25 is a cross section of the directional coupler type modulator according to the seventeenth embodiment.

DETAILED DESCRIPTION

FIG. 3 illustrates a directional coupler modulator 100 according to a first embodiment of the present invention. Fig. 4 illustrates a cross-sectional view of the directional coupler modulator 100 across the center of the element, which corresponds to the position for example of section 3-3 of FIG. 3.

The optical modulator formed of optical waveguides 32, 33